

# New species of Late Cretaceous Cypraeidae (Gastropoda) from California and British Columbia and new records from the Pacific slope

Lindsey T. Groves

Natural History Museum of Los  
Angeles County  
Malacology Section  
900 Exposition Boulevard  
Los Angeles, CA 90007 USA  
lgroves@nhm.org

## ABSTRACT

Cretaceous cypraeids are uncommon in North American strata and comprise 15 recognized species, seven of which are from the Pacific slope of North America (Groves, 1990). Four new species are described herein from localities in southern and northern California and British Columbia, Canada: *Palaeocypraea (Palaeocypraea) wilfredi* new species and *Bernaya (Bernaya) jeanae* new species, both from the Upper Cretaceous (lower Campanian) Chico Formation, Butte County, California; *Bernaya (Bernaya) beardi* new species from the Upper Cretaceous (uppermost Santonian to lowermost Campanian) upper Haslam Formation, Vancouver Island, British Columbia, Canada; and *Bernaya (Protoocypraea) popenoei* new species from the Upper Cretaceous (lower Campanian) Ladd Formation, Orange County, California. The late Campanian to early Maastriichtian was the Mesozoic peak of cypraeids, in terms of numbers of species and geographic distribution both in North America and worldwide (Groves, 1994). New paleogeographic and chronologic records of previously described species and indeterminate species are listed as well.

## INTRODUCTION

Four new Late Cretaceous species of cypraeid gastropods, uncommon in strata of that geologic age in North America, are described from localities in Orange and Butte counties, California, and Vancouver Island, British Columbia (Figure 1). Two are from the lower Campanian Chico Formation, Butte County, California; the third is from the uppermost Santonian to lowermost Campanian upper Haslam Formation, near Brannen Lake, Vancouver Island, British Columbia, Canada; and the fourth new species is from the lower Campanian Holz Shale Member of the Ladd Formation, Santa Ana Mountains, Orange County, California. Cypraeid records from the Chico and Ladd formations are recorded here for the first time.

## STRATIGRAPHY AND GEOLOGIC AGE

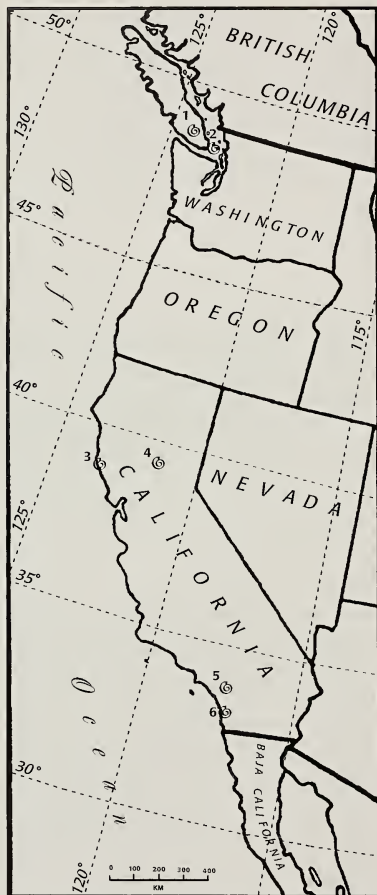
The formations listed below, from oldest to youngest, are those from which the new cypraeid taxa are described. Squires and Saul (2001) recently described several new species of gastropods from these formations and discussed their geologic age, stratigraphy, and paleoenvironment. Therefore, only a brief overview of stratigraphic nomenclature and age of the units will be discussed and readers are referred to additional sources for detailed descriptions.

### HASLAM FORMATION

The Haslam Formation of Clapp (1912) was described for outcrops on southeastern Vancouver Island, British Columbia. Based on ammonite biostratigraphy, Muller and Jeletzky (1970) cited the age of the formation as late Santonian to early Campanian, as did Ward (1978) and Haggart (1991). Squires and Saul (2001) concurred with a late Santonian to early Campanian age for the formation and indicated that magnetostratigraphic analysis could more precisely refine the stage boundary. Magnetostratigraphic work by Enkin et al. (2001 and pers. commun.) indicated that the formation was entirely Campanian. However, most recently Mustard et al. (2003 and pers. commun.) concluded that the formation was diachronous and contained both late Santonian and early Campanian fossils.

### PENTZ ROAD MEMBER OF THE CHICO FORMATION

Russell et al. (1986) described the informal Pentz Road member of the Chico Formation for outcrops near "Pence's Ranch" (= Pentz), Butte County, northern California. Based on the presence of the ammonites *Submortonicerias chicoense* (Trask, 1856) and *Baculites chicoensis* (Trask, 1856), they assigned an early Campanian age to these outcrops. Interestingly, Haggart et al. (1997)



**Figure 1.** Index map showing type localities for new taxa and other pertinent geographic areas mentioned in the text (modified with permission from Squires and Saul, 2001). 1 = Vancouver Island, British Columbia; 2 = Sucia Island, San Juan County, Washington; 3 = Gualala, Mendocino County, California; 4 = Pentz, Butte County, California; 5 = Santa Ana Mountains, Orange County, California; 6 = Carlsbad, San Diego County, California.

informally named a Pentz member for the same beds described by Russell et al. (1986) and interpreted these facies as a very nearshore shallow-marine environment. Squires and Saul (1997; 2001) concurred with the early Campanian age; based on the presence of the soft-bottom dwelling gastropod *Boggisia tenuis* (Gabb, 1864), however, they also interpreted the paleoenvironment as shallow marine rather than the estuarine environment reported by Russell et al. (1986).

#### HOLZ SHALE MEMBER OF THE LADD FORMATION

Popenoe (1942) described the Holz Shale Member of the Ladd Formation for lower Campanian outcrops in Ladd Canyon, Santa Ana Mountains, Orange County, California. The fossiliferous upper part of the member is dominated by sandstone beds deposited in a deep-shelf environment (Squires and Saul, 2001).

#### ABBREVIATIONS

Abbreviations used for institutional catalog and/or locality numbers are as follows: CAS, California Academy of Sciences, San Francisco; CIT, California Institute of Technology (collections now at LACMIP); LACMIP, Natural History Museum of Los Angeles County, Invertebrate Paleontology Section; RBCM, Royal British Columbia Museum, Vancouver; SCS, Sierra College, Rocklin, California; SDSNH, San Diego Society of Natural History; UCLA, University of California, Los Angeles (collections now at LACMIP); UCMP, University of California, Museum of Paleontology, Berkeley; USGS, United States Geological Survey, Menlo Park, California (collections now at UCMP); and VIPM, Vancouver Island Paleontological Museum, Qualicum Beach, Vancouver Island, British Columbia, Canada. Measurement parameters are defined as follows: length = greatest distance between anterior and posterior ends; width = greatest distance between lateral margins; and height = greatest distance between base and dorsum. The systematic classification herein follows that of Schilder and Schilder (1971).

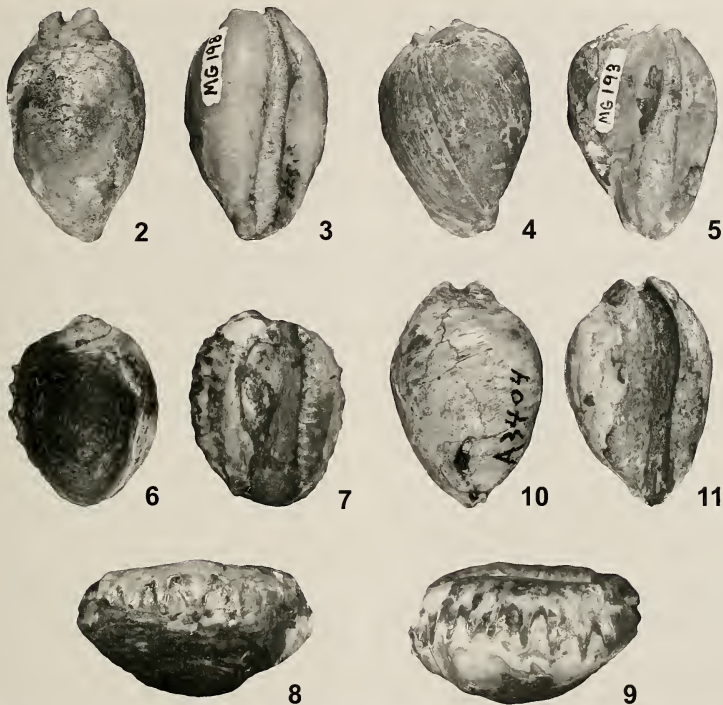
#### SYSTEMATIC PALEONTOLOGY

Superfamily Cypraeoidea Rafinesque, 1815  
 Family Cypraeidae Rafinesque, 1815  
 Subfamily Bernayinae Schilder, 1927  
 Tribe Archicypraeini Schilder, 1927  
 Genus *Palaeocypraea* Schilder, 1928

**Type Species:** *Cypraeacites spiratus* Schlotheim, 1820 by original designation. Early Paleocene (Danian), Faxø, Denmark.

**Diagnosis:** Shell small to medium in size, elongated, spire broad and partially covered, aperture wide with deep terminal canals and fine dentition; fossula broad, concave and smooth.

**Remarks:** Schilder and Schilder (1971) recognized



**Figures 2, 3.** *Palaeocypraea (Palaeocypraea) wilfredi* new species, holotype, LACMIP 13065, from LACMIP loc. 17611, 35.8 mm length. **Figures 4, 5.** *Bernaya (Bernaya) jeanae* new species, holotype, LACMIP 13067, from LACMIP loc. 17611, 42.4 mm length. **Figures 6–9.** *Bernaya (Bernaya) beardi* new species, holotype RBCM.EH2003.005.0001, from Vancouver Island, British Columbia, 36.7 mm length. **Figures 10, 11.** *Bernaya (Protocypraea) popenoei* new species, holotype UCMP 154951, from UCMP loc. A3404, 31.4 mm length.

nine species and 10 subspecies of Cretaceous *Palaeocypraea* s.s. Of these, six are from North America and two are from the Pacific slope (Groves, 1990). *Palaeocypraea (Palaeocypraea) fontana* (Anderson, 1958) from the Lower Cretaceous (uppermost lower Albian), Budden Canyon Formation, Shasta County, California, is the earliest known cypraeoidean from the Western Hemisphere. Other North American species are from San Juan County, Washington, Navarro County, Texas, New Castle County, Delaware, and Dawson County, Montana (Groves, 1990).

#### Subgenus *Palaeocypraea* Schilder, 1928

*Palaeocypraea (Palaeocypraea) wilfredi* new species (Figures 2–3)

**Diagnosis:** A *Palaeocypraea* of medium size, elongate shell, broad spire, fine dentition, fossula concave and smooth.

**Description:** Shell medium in size, slightly constricted anteriorly; maximum height and width near center; spire of medium height, partially covered by successive whorls; dorsum slightly flattened; aperture narrow, fairly

straight; denticulation fine with smooth interstices, outer lip with 18 teeth, inner lip with six teeth; outer lip with prominent anterior terminal ridge, forming slight marginal callus.

**Comparison:** The new species is most similar to *Palaeocypraea* (*Palaeocypraea*) *suciensis* (Whiteaves, 1895: 127–128, pl. 3, fig. 5) from the Upper Cretaceous (lower Campanian) Cedar District Formation, Nanaimo Group, Sucia Island, San Juan County, Washington. *Palaeocypraea* (*Palaeocypraea*) *wilfredi* is larger, has finer apertural dentition, a narrower aperture, shallower anterior and posterior canals, and a more cylindrical shape than *P. (P.) suciensis*.

**Discussion:** Although post-burial crushing has damaged part of the posterior dorsum, preservation is adequate enough for unequivocal generic and subgeneric assignments. *Palaeocypraea* (*P.*) *wilfredi* is the first cypracoidean reported from the Chico Formation.

**Material:** The new species is represented by two specimens. The holotype is slightly crushed, with minor amounts of original-shell material missing. The paratype exhibits small amounts of original-shell material but prominently displays the spire. An anterior outer lip fragment that exhibits original shell material from LACMIP loc. 24081 is also attributable to the new species.

**Type Material:** Holotype LACMIP 13065, paratype LACMIP 13066. Holotype measures 35.8 mm in length, 20.7 mm in width, and 17.0 mm in height. Paratype measures 34.8 mm in length, 20.6 mm in width, and 16.6 mm in height.

**Type Locality:** LACMIP loc. 17611, along Dry Creek, near Pentz, Butte County, California. Upper Cretaceous (lower Campanian), informal Pentz Road member, Chico Formation.

**Etymology:** Named after Wilfred Göhre (father of Eric Göhre, who collected and donated the type material to LACMIP) of Oroville, California.

Tribe Bernayini Schilder, 1927

Genus *Bernaya* Jousseau, 1884

**Type Species:** *Cypraea media* Deshayes, 1835, by original designation. Upper middle Eocene (Bartonian Stage), Auvers-sur-Oise, Val-d'Oise, France.

**Diagnosis:** Shell medium to large in size, anterior end somewhat carinate, dorsum smooth, spire of medium height and partially covered by successive whorls, aperture wide, sides rounded, anterior and posterior canals deep, fossula smooth, concave, wide.

**Remarks:** Schilder and Schilder (1971) recognized six species and two subspecies of Cretaceous *Bernaya* *s.s.* Only one of these is from North America; *Bernaya* (*Bernaya*) *burlingtonensis* (Schilder, 1932) from the Upper Cretaceous (upper Campanian), Mt. Laurel-Navesink Formation, Burlington County, New Jersey. Groves

(1990) described *B. (B.) crawfordcatei*, the first reported *Bernaya* *s.s.* from the Pacific slope, from the Upper Cretaceous (uppermost Campanian to lowermost Maastriichtian), Point Loma Formation, near Carlsbad, northern San Diego County, California.

*Bernaya* (*Bernaya*) *jeanae* new species  
(Figures 4–5)

**Diagnosis:** A *Bernaya* of medium size, anterior and posterior canals deep, spire of medium height, fossula smooth, concave, anterior and posterior terminal ridges prominent extending to margins.

**Description:** Shell medium in size, constricted anteriorly; maximum height and width posterior to center; spire of medium height, partially covered by successive whorls; aperture wide, straight; denticulation faint, outer lip with 13 teeth, teeth absent from inner lip; outer lip with prominent anterior and posterior terminal ridges extending to margins forming slight marginal callus.

**Comparison:** The new species is most similar to *Bernaya* (*Bernaya*) *crawfordcatei* Groves, 1990: 278, figs. 17–18, from the Upper Cretaceous (uppermost Campanian to lowermost Maastriichtian), Point Loma Formation, San Diego County, California. *Bernaya* (*Bernaya*) *jeanae* is smaller in size, has finer apertural dentition, less prominent anterior and posterior basal ridges, and a less sinuous aperture than *B. (B.) crawfordcatei*.

**Discussion:** Post-burial crushing has damaged parts of the aperture and dorso-ventrally distorted the type material. Generic and subgeneric assignment are based on the wide aperture, deep anterior and posterior canals, and medium-height spire. Along with *Palaeocypraea* (*P.*) *wilfredi* (described above), this is the second cypracoidean described from the Chico Formation.

**Material:** The new species is represented by the well preserved holotype and paratype, both of which exhibit original-shell material. Topotypic material includes 14 specimens in the collection of Eric Göhre, Oroville California, with varying amounts of original shell material. A single outer lip fragment from LACMIP loc. 24081 is assigned to the new species. A poorly preserved internal mold from the Chico Formation at the Granite Bay subdivision, Placer County, California (SC MG135) is attributable to the new species. An unusually large, poorly preserved specimen from Dry Creek near Pentz that measures 115.2 mm in length, 72.3 mm in width, and 38.7 mm, is tentatively identified as the new species.

**Type Material:** Holotype LACMIP 13067, paratype LACMIP 13068. Holotype measures 42.4 mm in length, 29.4 mm in width, and 19.8 mm in height. Paratype measures 47.1 mm in length, 30.6 mm in width, and 21.5 mm in height.

**Type Locality:** LACMIP loc. 17611, along Dry Creek, near Pentz, Butte County, California. Upper Cretaceous



(lower Campanian), informal Pentz Road member, Chico Formation.

**Etymology:** Named after Jean Göhre (mother of Eric Göhre, who collected and donated the type material to LACMIP) of Oroville, California.

*Bernaya (Bernaya) beardi* new species  
(Figures 6–9)

*Bernaya craufordcatei* Groves, 1990: Ludvigsen and Beard, 1994: 93, fig. 58 (left 2 figs.). Ludvigsen and Beard, 1997: 113, fig. 69 (left 2 figs.).

*Bernaya (Bernaya)* n. sp.: Groves, 1997: 7.

**Diagnosis:** A *Bernaya* of medium size, spire of medium height, aperture wide; fossula smooth, concave, anterior terminal canal deep.

**Description:** Shell medium in size; maximum height and width slightly posterior to center; spire of medium height, partially covered by successive whorls; aperture wide, straight; denticulation coarse with smooth interstices, outer lip with 13 teeth, teeth obsolete from inner lip; outer lip with weak posterior terminal ridge forming slight callus; marginal callus extends toward dorsum from outer and inner lip margins, forming coarse denticular pattern.

**Comparison:** The new species is unlike any known species of *Bernaya* (B.) in the Western Hemisphere although it superficially resembles *B. (B.) azevedoi* (Oliveira, 1957: 20, pl. 2, figs. 1, 3) from Upper Cretaceous (Maastrichtian) strata, Pernambuco State, Brazil and, *B. (Protocypraea) argonautica* (Anderson, 1958: 177, pl. 21, figs. 4–4a) from Upper Cretaceous (Cenomanian to Turonian) Hornbrook Formation, Osburger Gulch Sandstone Member (of Nilsen, 1954), Jackson County, Oregon. However, both species are markedly smaller than *B. (B.) beardi* and both are poorly preserved internal molds with little original-shell material preserved.

**Discussion:** Post-burial processes have removed much of the original-shell material from the dorsal surface of the holotype and the anterior terminal canal area is missing due to mechanical breakage. Generic and subgeneric assignments are based on the wide aperture, deep-posterior terminal canal, and spire of medium height. The unusual coarse marginal denticular pattern could be natural or an artifact of erosional processes. If this denticular pattern is indeed natural, it is unprecedented amongst cypraeids. Only species of the Eocene to Recent genus *Nucleolaria* Oyama, 1959, some members of the Recent genus *Cypraeovula* Gray, 1824, the Miocene to Recent species *Ipsa childreni* (Gray, 1825), and the Pleistocene to Recent species *Erosaria guttata* (Gmelin, 1791), have any outwardly similar marginal sculpture. *Bernaya (B.) beardi* appears to represent the northernmost record for a Cretaceous cypraeid worldwide. However, recent paleomagnetic paleolatitudinal studies by Kodama and Ward (2001) indicate that deposition of Nanaimo Basin sediments may have occurred at or around

40° N latitude (northern California) and transported northward in the post Late-Cretaceous. Enkin et al. (2001) concluded that the Nanaimo Basin was deposited near the present day California-Mexico border also based on paleomagnetic evidence. They also noted that this interpretation conflicts with sedimentologic and paleontologic evidence established by Elder and Sael (1993) and Haggart (2000) that the Nanaimo Basin was deposited near its present northern position.

**Material:** Represented by a well preserved holotype and three slightly juvenile topotypic specimens (VIPM 144, 146, and 147), all of which exhibit varying amounts of original shell material.

**Type Material:** Holotype RBCM.EH2003.005.0001 (ex VIPM 148), 36.7 mm in length, 28.9 mm in width, and 21.4 mm in height.

**Type Locality:** Near Brannen Lake, Vancouver Island, British Columbia, Canada, Upper Cretaceous (uppermost Santonian to lowermost Campanian), upper Haslam Formation, Nanaimo Group.

**Etymology:** Named after Graham Beard, founder of the Vancouver Island Paleontological Museum, Qualicum Beach, Vancouver Island, British Columbia, Canada.

Subgenus *Protocypraea* Schilder, 1927

**Type Species:** *Eocypraea orbignyana* Vredenburg, 1920 by original designation. Upper Cretaceous (Turonian through Santonian), Trichinopoly Group, Kullygoody, southern India.

**Diagnosis:** Shell small to medium in size, shape moderately pyriform, somewhat constricted anteriorly; fossula smooth, concave, wide.

**Remarks:** Schilder and Schilder (1971) recognized eight species and seven subspecies of Cretaceous *Bernaya* (*Protocypraea*). Two of their species [*B. (P.) argonautica* and *B. (P.) berryssae* both (Anderson, 1958)] and one subspecies, now recognized as a full species [*B. (P.) gualalaensis* (Anderson, 1958)], are from the Pacific slope of North America. Groves (1990) described *B. (P.) rineyi* from the Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation, near Carlsbad, northern San Diego County, California. The only other North American species, *Bernaya (Protocypraea) mississippiensis* Groves (1990), is from the Upper Cretaceous (Campanian), Coffee Formation, Lee County, Mississippi.

*Bernaya (Protocypraea) popenoei* new species  
(Figures 10–11)

*Bernaya (Protocypraea)* n. sp.: Groves, 1997: 7.

**Diagnosis:** Pyriform *Protocypraea*, posterior terminal ridges forming slight marginal callus; fossula concave, smooth.

**Description:** Shell of medium size, moderately inflated, elongate and somewhat constricted anteriorly; spire partially covered by successive whorls; dorsum moderately arched; maximum height and width slightly posterior of center; aperture somewhat straight, narrow; teeth absent from both outer and inner lips; fossula concave, smooth, wide; posterior basal terminal ridges forming slight marginal callus; anterior and posterior terminal canals shallow.

**Comparison:** The new species is most similar to *Bernaya* (*Protocypraea*) *gualalaensis* (Anderson, 1958: 176, pl. 62, figs. 8–8a) from the Upper Cretaceous (upper Campanian to lower Maastrichtian) Gualala Formation, informal Anchor Bay member of Wentworth (1966) (see also Elder et al., 1998), Mendocino County, northern California. *Bernaya* (*Protocypraea*) *popenoei* is smaller than *B. (P.) gualalaensis* and has a narrower and straighter aperture, and more globose shape.

**Description:** Good preservation of the holotype permits unequivocal generic and subgeneric assignments. Although the Upper Cretaceous rocks of the Santa Ana Mountains, Orange County, California contain abundant mollusks (Packard, 1922; Popenoe, 1937, 1942; Saul, 1982, 1996), *B. (P.) popenoei* is the only cypraeoidaen so far described from the Ladd Formation.

**Material:** Represented by a single well preserved specimen that exhibits original-shell material.

**Type Material:** Holotype, UCMP 154951, measures 31.4 mm in length, 20.2 mm in width, and 17.8 mm in height.

**Type Locality:** UCMP loc. A3404, Lucas Canyon, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California, Upper Cretaceous (lower Campanian), Ladd Formation, Holz Shale Member.

**Etymology:** Named for the late Willis Parkinson ("Parky") Popenoe (University of California, Los Angeles), in recognition of his numerous significant contributions to Cretaceous paleontology and stratigraphy of the Santa Ana Mountains, Orange County, California.

#### NEW RECORDS OF PACIFIC SLOPE CRETACEOUS CYPRAEIDS

*Bernaya* (*Bernaya*) *craftfordcatei* Groves, 1990

**New Record:** LACMIP loc. 17198, west side of Bee Canyon, El Toro quadrangle (1949 ed.), Santa Ana Mountains, Orange County, California. Upper Cretaceous (upper lower Campanian), Williams Formation, Pleasants Sandstone Member. Poorly preserved internal mold.

**Distribution:** Formerly restricted to the *B. (B.) craftfordcatei* type locality (SDSNH loc. 3392), Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation, near Carlsbad, northern San Diego County, California.

*Bernaya* (*Protocypraea*) *gualalaensis* (Anderson, 1958)

**New Record:** USGS Mesozoic loc. M8829 north side of Haven's Neck, Mendocino County, California. Upper Cretaceous (upper Campanian to lower Maastrichtian), Gualala Formation, informal Anchor Bay member. Two fairly well preserved internal molds were illustrated by Elder et al. (1998: 152, 163, pl. 1, figs. 2–3, 6).

**Distribution:** Type locality (CAS loc. 61915), near Gualala, Mendocino County, to the Carlsbad area, northern San Diego County, California (SDSNH locs. 3162, 3162-A, 3162-B, 3162-M, 3392, 3405, and 3454), Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation.

*Palaeocypraea* sp.

**New Record:** LACMIP loc. 10441 (*ex* CIT loc. 1396), Sucia Island, San Juan County, Washington. Upper Cretaceous (lower Campanian), Cedar District Formation. Single, fairly well preserved, slightly dorso-ventrally crushed, juvenile specimen.

Cypraeidae, undetermined genus and species.

**New Record:** LACMIP loc. 17421, Palmer Way, Carlsbad, San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian) Point Loma Formation. Single poorly preserved internal mold.

#### ACKNOWLEDGMENTS

Eric Göhre, Oroville, California, generously loaned specimens from his personal collection for this project, donated type material to LACMIP, and arranged for access to and accompanied the author on private property along Dry Creek, near Pentz, Butte County, California. Without his collecting skills, enthusiasm, and generosity, a major portion of this paper would not have been possible. Richard P. Hilton (Sierra College, Rocklin, California), LouElla R. Saul (LACMIP), and Richard L. Squires (California State University, Northridge, Geological Sciences) also accompanied the author in the field. Special thanks to Graham Beard (VIPM) and David Lindberg (UCMP) for specimen loans from their respective institutions. LouElla R. Saul (LACMIP) expertly removed matrix from several specimens, discussed stratigraphic problems, and allowed access to her personal library. Peter S. Mustard (Simon Fraser University, Burnaby, British Columbia) and Randy J. Emkin (Geological Survey of Canada, Sydney, British Columbia) are thanked for reprints and detailed discussions of Haslam Formation age and paleomagnetism of the Nanaimo Basin. I thank Tom Cockburn, Victoria Palaeontological Society, British Columbia for his assistance in acquiring key references and making important contacts. Ellen Kim (LACM Malacology volunteer) assisted with digital photography and

Ángel Valdés (LACM Malacology) kindly assisted with digital image manipulations.

Don McNamee and Mali Griffin (Natural History Museum of Los Angeles County, Research Library) expertly assisted in locating obscure references. Many thanks to LouElla R. Saul (LACMIP), Richard L. Squires (CSUN), and James H. McLean and Ángel Valdés (LACM Malacology) for reviewing an early draft of the manuscript. The evaluations of James G. Haggart (Geological Survey of Canada, Vancouver, British Columbia) and an anonymous reviewer greatly enhanced this paper.

## LITERATURE CITED

- Anderson, F. M. 1958. Upper Cretaceous of the Pacific Coast. Geological Society of America, Memoir 71, 375 pp., 75 pls.
- Clapp, C. H. 1912. Geology of Nanaimo Sheet, Nanaimo coalfield, Vancouver Island, British Columbia. Summary Report of the Geological Survey Branch of the Department of Mines for 1911: 91–105.
- Deshayes, G. P. 1824–1837. Description des coquilles fossiles des environs de Paris. F.-G. Levrault, Paris, 1 [Conchifères]: 1–392 [1824]; 2 [Mollusques]: 1–783 [1824–1835]; Atlas, pls. 1–101 [1837].
- Elder, W. P. and L. R. Saul. 1993. Paleogeographic implications of molluscan assemblages in the Upper Cretaceous (Campanian) Pigeon Point Formation, California. In: Dunn, G. and McDougall, K. (eds.) Mesozoic paleogeography of the western United States—II. Society of Economic Paleontologists and Mineralogists, Pacific Section Guidebook 71: 171–186, figs. 1–4, pls. 1–2.
- Elder, W. P., L. R. Saul and C. L. Powell II. 1998. Late Cretaceous and Paleogene fossils of the Gualala Block and their paleogeographic implications. In: Elder, W. P. (ed.), Geology and tectonics of the Gualala Block, northern California. Society of Economic Paleontologists and Mineralogists, Pacific Section Guidebook 84: 149–168, figs. 1–3, pl. 1.
- Enkin, R. J., J. Baker and P. S. Mustard. 2001. Paleomagnetism of the Upper Cretaceous Nanaimo Group, southwestern Canadian Cordillera. Canadian Journal of Earth Sciences 38: 1403–1422, figs. 1–9.
- Cabb, W. M. 1864. Description of the Cretaceous fossils. Geological Survey of California, Paleontology 1: 57–217, pls. 9–32.
- Gmelin, J. F. 1791. Caroli a Linné Systema naturae per regna tria naturae. Editio decimo tertia. 1(6): 3021–3910, Leipzig, Germany.
- Gray, J. E. 1824–1828. Monograph on the Cypraeidae, a Family of Testaceous Mollusca. Zoological Journal 1: 71–80, 137–152 [1824]; 1: 367–391 [1824]; 1: 489–518 [1825]; 3: 363–371 [1827]; 3: 567–576; 4: 66–88 [1828].
- Groves, L. T. 1990. New species of Late Cretaceous Cypraeacea (Mollusca: Gastropoda) from California and Mississippi, and a review of Cretaceous cypraeaceans of North America. The Veliger 33: 272–285, figs. 1–34.
- Groves, L. T. 1994. Jurassic and Cretaceous cypraeacean biogeography and paleontology with an annotated list of the species. The Cowry, new series 1: 25–41, figs. 1–20.
- Groves, L. T. 1997. Fossil and Recent species of eastern Pacific Cypraeacea (Cypraeidae and Eocypraeinae [Ovulidae]): An update [extended abstract]. Western Society of Malacologists, Annual Report 29: 7–10.
- Haggart, J. W. 1991. Biostratigraphy of the Upper Cretaceous Nanaimo Group, Gulf Islands, British Columbia. In: Smith, P.L. (ed.), A field guide to the paleontology of southwestern Canada. University of British Columbia, Vancouver, pp. 223–257.
- Haggart, J. W., L. R. Saul, R. Watkins and E. S. Göhre. 1997. Cretaceous shallow marine strata at Pentz, California. In: Erskine, M. and D. Lawler (eds.) Northern Sierra Nevada Regional Geological Field trip Guidebook, Northern California Geological Society, pp. 1–6.
- Joussemaie, F. P. 1854. Étude sur la famille des Cypraeidae. Bulletin de la Société Zoologique de France 9: 81–100.
- Kodama, K. P. and P. D. Ward. 2001. Compaction-corrected paleomagnetic paleolatitudes for Late Cretaceous rudists along the Cretaceous California margin: Evidence for less than 1500 km of post-Cretaceous offset for Baja British Columbia. Geological Society of America Bulletin 113: 1171–1178, figs. 1–3.
- Ludvigsen, R. and C. Beard. 1994. West coast fossils: A guide to the ancient life of Vancouver Island. Whitecap Books, Vancouver, xii + 194 p., 130 figs.
- Ludvigsen, R. and C. Beard. 1997. West coast fossils: A guide to the ancient life of Vancouver Island. Second edition. Harbour Publishing, Madeira Park, British Columbia, 216 pp., 157 figs.
- Muller, J. E. and J. A. Jezletzky. 1970. Geology of the Upper Cretaceous Nanaimo Group, Vancouver Island and Gulf Islands, British Columbia. Geological Survey of Canada Paper 69-25: 1–77.
- Mustard, P., J. Haggart, D. Katnick, K. Treptau and J. MacEachern. 2003. Sedimentology, paleontology, ichnology and sequence stratigraphy of the Upper Cretaceous Nanaimo Group submarine fan deposits, Denman and Hornby islands, British Columbia. In: Geological field trips in southern British Columbia. Geological Association of Canada Cordilleran Section, pp. 103–145, figs. 1–27.
- Nilsen, T. H. 1984. Tectonics and sedimentation of the Upper Cretaceous Hornbrook Formation, Oregon and California. In: Crouch, J. K. and Bachman, S. B. (eds.), Tectonics and sedimentation along the California margin. Society of Economic Sedimentologists and Paleontologists, Pacific Section Guidebook 42: 101–118, figs. 1–7.
- Oliveira, P. E. de. 1957. Invertebrados Cretácicos do fosfato de Pernambuco. Divisão de Geologia e Mineralogia Rio de Janeiro, Boletim 172: 1–29, pls. 1–2.
- Oyama, K. 1959. Review of nomenclature on Japanese shells (3). Venus 20: 361–362.
- Packard, E. L. 1922. New species from the Cretaceous of the Santa Ana Mountains, California. University of California Publications, Bulletin of the Department of Geological Sciences 13: 413–462, pls. 24–38.
- Popenoe, W. P. 1937. Upper Cretaceous Mollusca from southern California. Journal of Paleontology 11: 379–402, pls. 45–49.
- Popenoe, W. P. 1942. Upper Cretaceous formations and faunas of southern California. Bulletin of the American Association of Petroleum Geologists 26: 162–187, figs. 1–4.
- Rafinesque, C. S. 1815. Analyse de la nature, ou tableau de l'univers et des corps organisés. Palermo, 224 pp.
- Russell, J. S., S. L. Baum and R. Watkins. 1986. Late Coniacian to Early Campanian clastic shelf deposits and molluscan assemblages of the northeastern Sacramento Valley, Cali-

- formia. In: Abbott, P. L. (ed.), Cretaceous stratigraphy, western North America. Society of Economic Paleontologists and Mineralogists, Pacific Section Guidebook 46: 179-196, figs. 1-16.
- Saul, L. R. 1982. Water depth indications from Late Cretaceous mollusks, Santa Ana Mountains, California. In: Bottjer, D. J. and others (eds.), Late Cretaceous depositional environments and paleogeography, Santa Ana Mountains, southern California. Society of Economic Paleontologists and Mineralogists, Pacific Section Guidebook 24: 69-75, figs. 1-3, 4 unnumbered figs.
- Saul, L. R. 1986. Three new Turonian muricean gastropods from the Santa Ana Mountains, southern California. The Veliger 39: 125-135.
- Schilder, F. A. 1927. Revision der Cypraea (Moll., Gastr.). Archiv für Naturgeschichte 91A(10): 1-171.
- Schilder, F. A. 1928. Die Cypraea des Daniums von Dänemark und Schonen. Danmark Geologiske Undersøgelse, ser. 4, 2(3): 1-29, figs. 1-16.
- Schilder, F. A. 1932. Cypraea. In: W. Quenstedt (ed.), Fossilium Catalogus, I: Animalia, pt. 55. W. Junk, Berlin, 276 pp.
- Schilder, M. and F. A. Schilder. 1971. A catalogue of fossil and living cowries. Institut Royal des Sciences Naturelles de Belgique, Mémoire 85: 1-246.
- Schlothem, E. F. 1820-1823. Die petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung versteinerter und fossilier überreste des Thürund Pflanzenreichs der Vorwelt erläutert, Beckerschen Buchhandlung, Gotha. xii + 437 pp. Atlas: pls. 15-29 [1820]; pls. 1-21 [1822]; pls. 22-37 [1823].
- Squires, R. L. and L. R. Saul. 1997. Late Cretaceous occurrences on the Pacific slope of North America of the melanopsid gastropod genus *Boggsia* Olsson, 1929. The Veliger 40: 193-202.
- Squires, R. L. and L. R. Saul. 2001. New Late Cretaceous gastropods from the Pacific slope of North America. Journal of Paleontology 75: 46-65.
- Trask, J. B. 1856. Description of a new species of ammonite and baculite from the Tertiary rocks of Chico Creek. Proceedings of the California Academy of Sciences, 1st ser. 1: 92-93, pl. 2.
- Vredenburg, E. W. 1920. Classification of the Recent and fossil Cypraeidae. Records of the Geological Survey of India 2: 65-152.
- Ward, P. D. 1978. Baculitids from the Santonian-Maastrichtian Nanaimo Group, British Columbia, Canada and Washington State, USA. Journal of Paleontology 52: 1143-1154.
- Wentworth, C. M. 1966. The Upper Cretaceous and lower Tertiary rocks in the Gualala area, northern Coast Ranges, California [Ph.D. dissertation]. Stanford University, Stanford, 197 pp.
- Whiteaves, J. F. 1895. On some fossils from the Nanaimo Group of the Vancouver Cretaceous. Transactions of the Royal Society of Canada, 2nd ser., 1: 119-133, pls. 1-3.
- Campanian to lower Maastrichtian), Gualala Formation. Coll.: S. G. Clark.
- LACMP 10441 (ex CIT loc. 1396). Bluffs along south side of Fossil Bay, south side and east end of Sucia Island, San Juan County, Washington. Upper Cretaceous (lower Campanian), Cedar District Formation. Coll.: R. Durbin, H. L. and W. P. Popenoe, 23 Jul, 1935.
- LACMP 17198. Unsorted very indurated conglomerate lens with pebble and cobble-sized clasts and a sandstone matrix; at elevation 207 m, on west side of divide on west side of Bee Canyon, 4496 m south and 3117 m east of northwest corner of USGS El Toro quadrangle (1949 ed.), Santa Ana Mountains, Orange County, California. Upper Cretaceous (upper lower Campanian), Williams Formation, Pleasants Sandstone Member. Coll.: P. Peck and others, 28 May, 1997. [Locality now inaccessible and covered by Eastern Transportation Corridor].
- LACMP 17421. In sandstone immediately overlying basal conglomerate and from spoil piles along south side of commercial property at 5607 Palmer Way, Carlsbad, San Luis Rey quadrangle (1975), San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: G. L. Kennedy.
- LACMP 17611. Dry Creek, near Pentz, Butte County, California. Upper Cretaceous (lower Campanian), informal Pentz Road member, Chico Formation. Coll.: E. S. Göhre.
- LACMP 24081 (ex UCLA loc. 4081). South of Pentz, Butte County, California. Upper Cretaceous (lower Campanian), informal Pentz Road member, Chico Formation. Coll.: T. Susuki.
- SDSNH 3162. Carlsbad area, locality (now covered by Faraday Avenue) was exposed during development of Carlsbad Research Center, southwest of El Camino Real, south of Letterbox Canyon and north of Palomar Airport, 33°08'02" N, 117°16'41" W, San Luis Rey quadrangle, San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, Mar-May, 1982.
- SDSNH 3162-A. Carlsbad area, at base of stratigraphic section measured at SDSNH 3162, approximately 6.1 m below a calcareous marker bed. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, Mar-May, 1982.
- SDSNH 3162-B. Carlsbad area, 2.1-3.9 m below a calcareous marker bed in measured stratigraphic section at SDSNH 3162. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney, T. A. Deméré, and M. A. Roeder, Mar-May, 1982.
- SDSNH 3162-M. Carlsbad area, near top of stratigraph-

## APPENDIX 1

## LOCALITIES CITED

CAS 61918 (ex S. G. Clark loc. 251). Near Gualala, sec. 27(?), T11N, R15W, MDMB, Gualala quadrangle, Mendocino County, California. Upper Cretaceous (upper



ic section measured at SDSNH 3162. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney, T. A. Deméré and M. A. Roeder.

SDSNH 3392. Carlsbad area, north of Palomar Airport, roadcut along west side of College Boulevard, approximately 424 m south of intersection with El Camino Real, 33°08'21" N, 117°17'02" W, San Luis Rey quadrangle, San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: SDSNH field party May, 1987.

SDSNH 3405. Carlsbad area, north of Palomar Airport, excavation for College Boulevard, approximately 242–485 m south of intersection with El Camino Real, 33°08'21" N, 117°17'02" W, San Luis Rey quadrangle, San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney, M. A. Roeder, and R. Q. Gutzler, Apr–May, 1987.

SDSNH 3454. Carlsbad area, north of Palomar Airport, excavation for College Boulevard, approximately 153 m north of College Boulevard and Faraday Avenue intersection, 33°08'11" N, 117°17'02" W, San Luis Rey quadrangle, San Diego County, California. Upper Cretaceous (uppermost Campanian to lowermost Maastrichtian), Point Loma Formation. Coll.: B. O. Riney and M. A. Roeder, Apr–May, 1987.

UCMP A3404. Fossils in float boulders in Lucas Canyon, a branch of San Juan Canyon, near San Juan Capistrano, Santiago Peak quadrangle, Santa Ana Mountains, Orange County, California. Upper Cretaceous (lower Campanian), Ladd Formation. September, 1916.

USGS Mesozoic loc. M8829. Conglomerate at northeast end of beach on north side of Haven's Neck in SW¼ SW¼ SE¼, section 12, T11N, R16W, Mendocino County, California. Upper Cretaceous (upper Campanian to lower Maastrichtian), Gualala Formation, informal Anchor Bay member. Coll.: W. P. Elder, 1992.